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Technical Reports on Seismology

An Investigation of Swell and Microseisms from the Hurricane of August 13-16, 1946

REPORT No.17

Lamont Geological Observatory

(Columbia University)

Palisades, New York

An Investigation of Swell and Microseisms From the Hurricane of August 13-16, 1946

Technical Report #17

by

William L. Donn ____________________

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ABSTRACT

Data from swell and microseism records associated with the hurricane of August 13-16, 1946 are compared. There appears to be no relationship between the period of the swell arriving at Cuttyhunk off Cape Cod and the period of microseisms recorded at nearby Weston Observatory. Time relationships tend to minimize the importance of swell or resulting surf as the microseism excitation factors. The origin of the microseisms is suggested as occurring directly beneath the storm.

INTRODUCTION

An attempt is made here to apply the methods of Deacon (1949) and Darbyshire (1950) and most recently Kammer and Dinger (1951) in comparing swell and microseism data from the same storm. A hurricane was used for this purpose rather than a larger cyclone since more precise locations could be made. This particular hurricane was selected owing to the pronounced variations in swell recorded from it which would therefore make obvious any correlation with microseism period that might be present. The swell records were made by an underwater pressure unit located at a depth of 78 feet off Cuttyhunk Island near the western end of Cape Cod ("R" on Fig. 1). Seismograms were obtained from Weston Observatory ("W" on Fig. 1), the nearest seismograph station.

COMPARISON OF DATA

Fig. 1 shows the path of the hurricane from September 13 to 16, with center positions marked for every six hours. It is apparent that the hurricane velocity increased as it traveled northeastward, and decreased temporarily near the end of its track. The broken line above the track is a curve of microseism amplitude plotted so that the perpendicular distance between the path and the broken line is proportional to actual trace amplitude of the microseisms recorded at Weston with the height and period of the swell recorded at

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[illegible]

[illegible]

Cuttyhunk. The technique of sampling and measuring the microseism and wave records is similar to that indicated earlier by Donn (1951) and Klebba (1949), respectively.

After the usual increase of microseism period with increasing amplitude, the period became level at 3.5 seconds, remaining so for the duration of the microseism storm. The earliest recorded storm swell, at 2400 GMT, September 14, was 17 seconds. Thereafter the swell period decreased to 8 seconds, apparently a function of the azimuth of the hurricane (Donn 1949). A series of swell spectra made by machine analysis of the original wave records show the narrow envelope of periods present (Fig. 3). The 11 second swell (Fig. 2) at 1800 on September 14 was the last of the prevailing swell prior to the first arrival of hurricane swell which commenced abruptly with a much higher period. There is further, no indication of the two to one ratio of swell period to microseism period reported empirically by Deacon (1949) and Darbyshire (1950) and predicted theoretically by Longuett-Higgins (1950) for microseisms supposedly originating from standing waves produced by interference of oppositely moving swell. This also contradicts the findings of Kammer and Dinger (1951) who did not have actual recordings of swell for comparison with microseism data.

The lack of any direct swell-microseism relationship is further strengthened by the time relation of the amplitude curves. The onset of the microseism storm was about 0600,

[illegible]

September 14, whereas the earliest storm swell reached the nearby coast between 1800 and 2400 of September 14. Further, the microseism storm declined to background level while storm swell was still being recorded at southeastern New England. This, and later swell generated with the hurricane North of the station must have existed northward along the coast at points even closer to the seismic station until well after the microseism storm reached background level. This further conflicts with the findings of Kammer and Dinger that the duration of microseism storms parallels the duration of swell received from a passing or retreating hurricane.

All of the above tends to minimize also the effect of surf as the exciting agent. It might be argued that the early phase of the microseism storm was produced by swell or surf at some distance, possibly along the middle Atlantic coast, most of which has gently sloping beach zones. But then it must be explained why the microseism storm did not continue while the swell was breaking on the rocky New England coast instead of declining to background. Further, owing to the distribution of wind velocities in this hurricane, and its distinctly elliptical shape elongated in the direction of motion, the swell that would have reached the middle coast zone is assumed to have been 9 seconds, being a function of the storm azimuth (Donn 1949). From this information, plus the high forward velocity of the hurricane, it is calculated

that the swell arriving along the east coast would have barely preceded that arriving at Cuttyhunk, and would have been well after the onset of microseisms. From a study of the weather maps it is estimated that the swell leaving the hurricane at the 0030 position on September 14 would probably have reached the coast near Cape Hatteras first. Using a group velocity of 13.5 knots appropriate to a 9 second swell, such swell should have reached the above coast approximately at 1530 on September 14, or well after the commencement of microseisms.

Examination of the amplitude curve plotted on the storm path, (Fig. 1) shows that with respect to the hurricane position, the microseism storm increased in intensity fairly uniformly as the hurricane approached, and then decreased rather abruptly. The abrupt decline corresponds to the time when most of the hurricane passed over Newfoundland and surrounding shoals, and was also dissipating rapidly. Peak microseism amplitudes occurred with most of the hurricane over the continental shelf rather than a little earlier when it would have been closest to the station. This is similar to the behavior of other hurricane microseism storms suggested earlier (Donn 1951) as an evidence of a discontinuity affecting microseism propagation along the edge of the shelf in this area.

Further, using appropriate group velocities, the position along the hurricane path corresponding to the time when

recorded swell left the storm has been determined. The earliest swell to arrive, when projected back in time thus left the storm approximately at the position shown by the arrow (Fig. 1). Hence the microseism storm had already commenced at Weston at approximately the time when the earliest recorded local hurricane swell was leaving the storm, and perhaps even earlier. This also tends to negate the possibility of progressive swell in shallow water off the coast from being a generating factor.

CONCLUSIONS

These observations tend to minimize the importance of swell or surf as the exciting mechanism for this microseism storm. They suggest again that the microseism origin lies in the area directly beneath the storm, and results from some coupling mechanism at the water-air interface.

If swell (and resulting surf) and microseisms are assumed to be generated simultaneously by different mechanisms in a storm area, rather than one dependent on the other, then an ambiguity in origin will often exist, especially if time relations are considered. Unique cases in which high winds and no swell or surf exist, or in which swell or surf and no high winds exist would be most helpful in discriminating between modes of microseism origin. The

latter case is unlikely unless the swell or surf is the product of a very distant storm. However, the former case, in which strong offshore winds following a cold front spread over coastal waters, and damp any onshore swell that may exist, occurs very frequently. Many such distinct cases have recently been cited by Donn (4,8) in which microseism storms commence almost exactly as strong offshore winds reach coastal waters, whereas only background microseisms often existed just previous to this, despite strong onshore swell-producing winds. A more extended study of simultaneous swell and microseism data is in progress.

ACKNOWLEDGEMENTS

Records for the microseism storm were obtained from Weston Observatory, and swell recordings and analyses were furnished by the Woods Hole Oceanographic Institution. We gratefully acknowledge the cooperation of these institutions.

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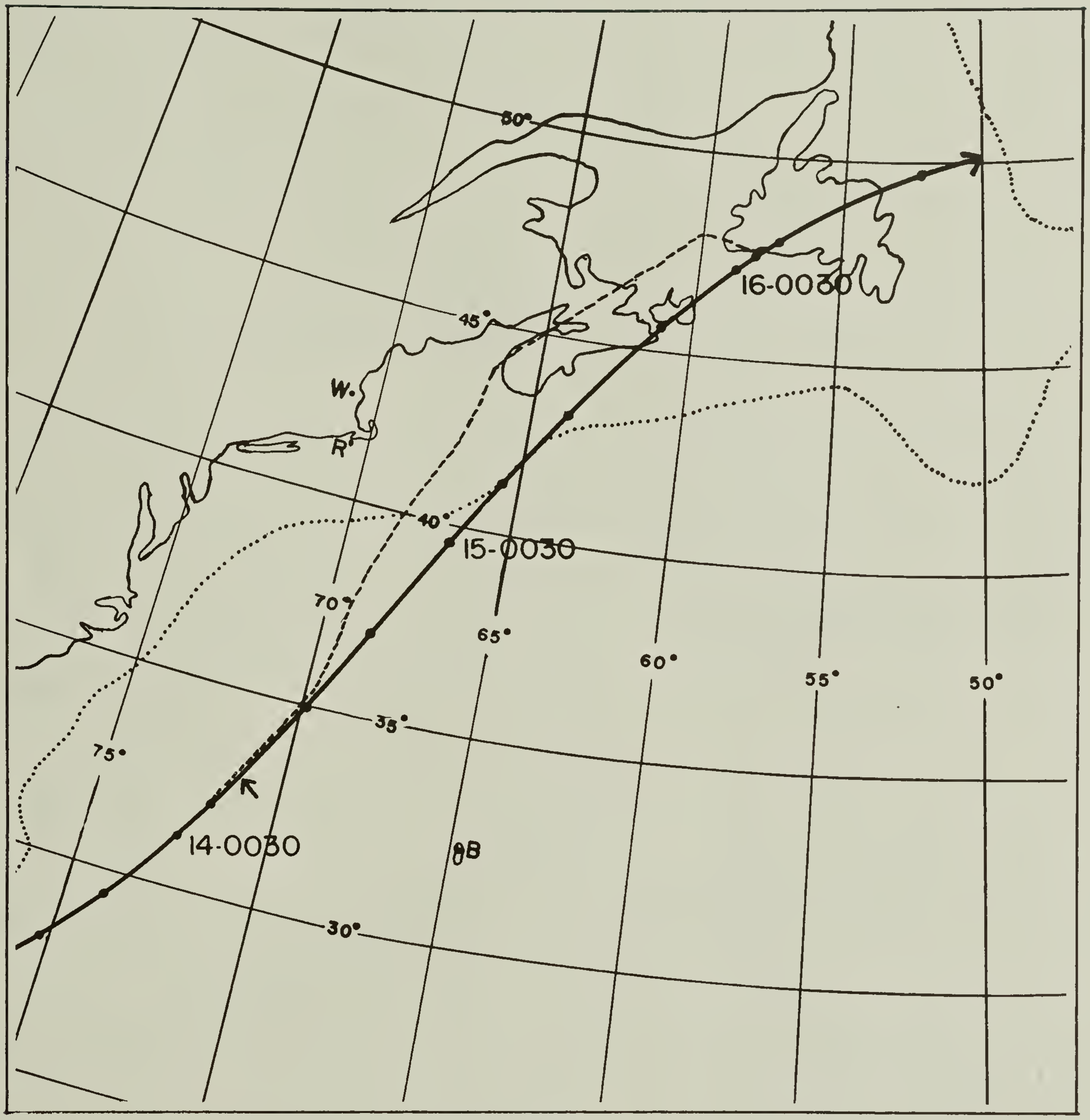

FIGURE I

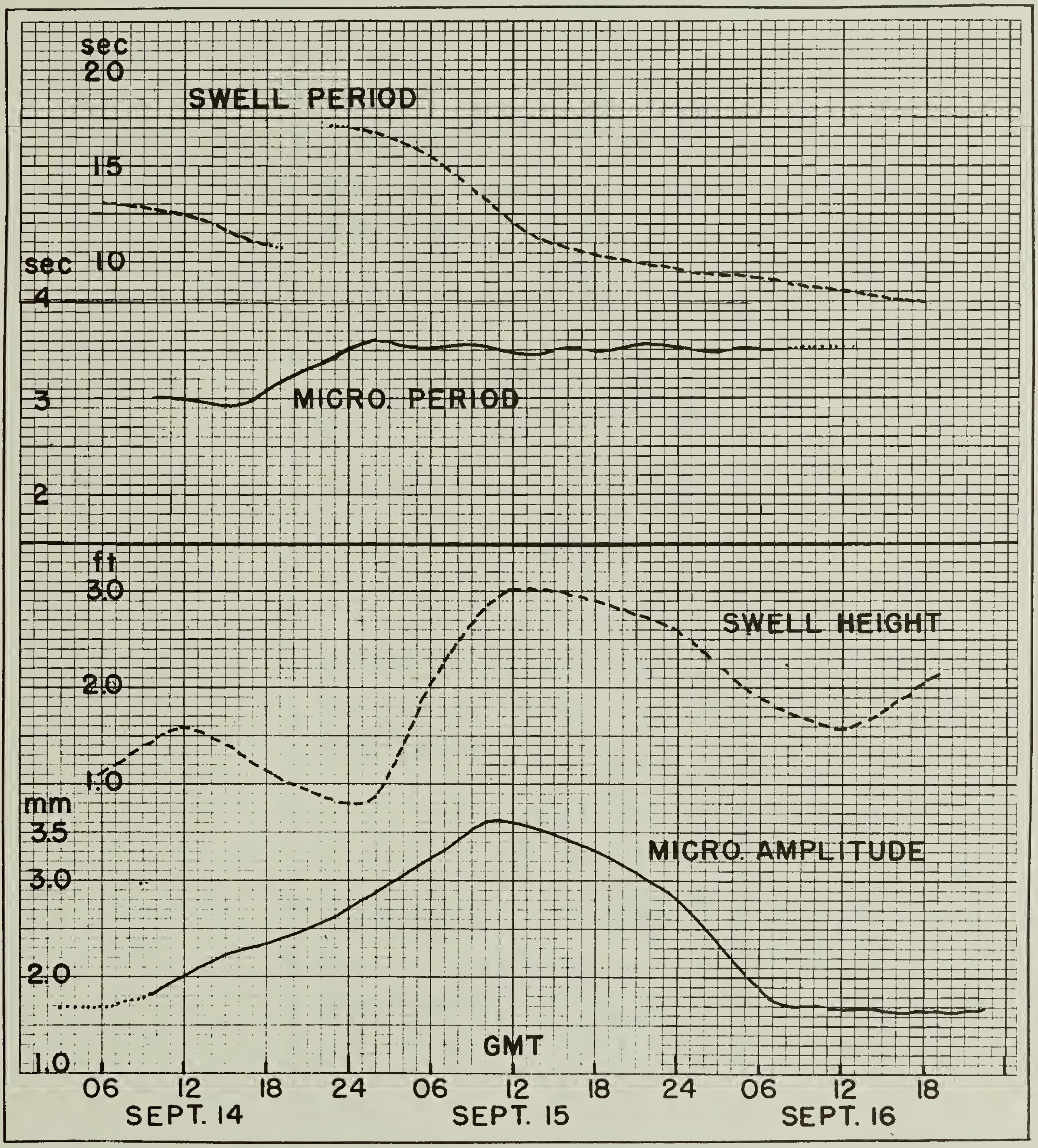
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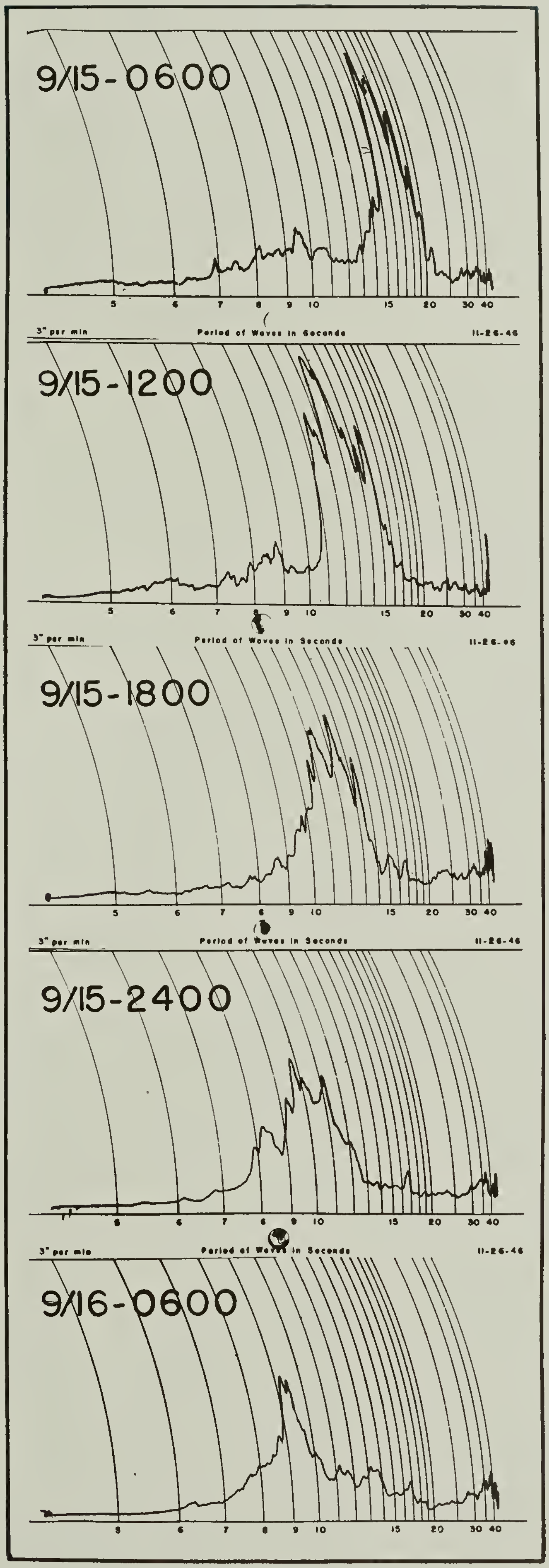
FIGURE 2



9/15-0600
5 6 7 8 9 10 15 20 30 40
3" per min
Period of Waves in Seconds
11-26-46
9/15-1200
5 6 7 8 9 10 15 20 30 40
3" per min
Period of Waves in Seconds
11-26-46
9/15-1800
5 6 7 8 9 10 15 20 30 40
3" per min
Period of Waves in Seconds
11-26-46
9/15-2400
5 6 7 8 9 10 15 20 30 40
3" per min
Period of Waves in Seconds
11-26-46
9/16-0600
5 6 7 8 9 10 15 20 30 40

FIGURE 3